



# AK1222

## 900MHz Low Power Mixer

### 1. Overview

The AK1222 is a low power mixer. RF and LO frequency range coverage from 100 to 900MHz and IF coverage is from 20 to 100MHz. The RF input provides single-ended 50Ω interface. LO ports are 50Ω matched and complementary inputs should be decoupled to the ground. IF output ports are differential open drain outputs.

The linearity and power consumption performances can optimize with the resistance connected to the BIAS pin.

### 2. Features

- Operating Frequency: 100 to 900MHz
- Linearity vs Power Selectable architecture
  - Power Consumption:5.3mA, IIP3:+11dBm, Gain:-2dB, NF:12dB
  - Power Consumption:2.9mA, IIP3:+2dBm, Gain:-3.5dB, NF:11.5dB
- LO input level: 0dBm±5dB
- Operating Supply Voltage: 4.75 to 5.25 V
- Package: 16pin UQFN (0.5mm pitch, 3mm x 3mm x 0.60mm)
- Operating Temperature Range: -40 to 85°C

### 3. Applications

- Two-way Radios (PMR/LMR)
- Radio Communications for disaster prevention
- Marine Radios
- Amateur Radios

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## 5. Block Diagram

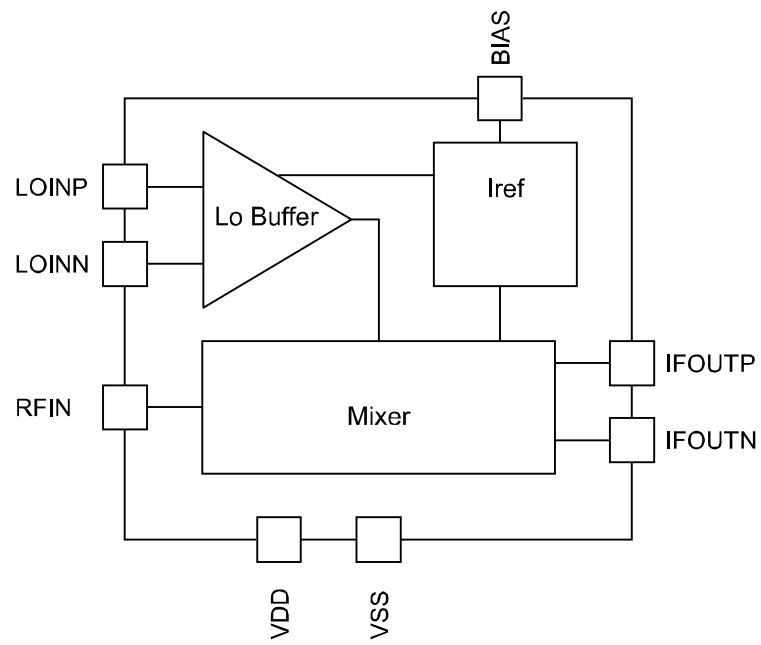
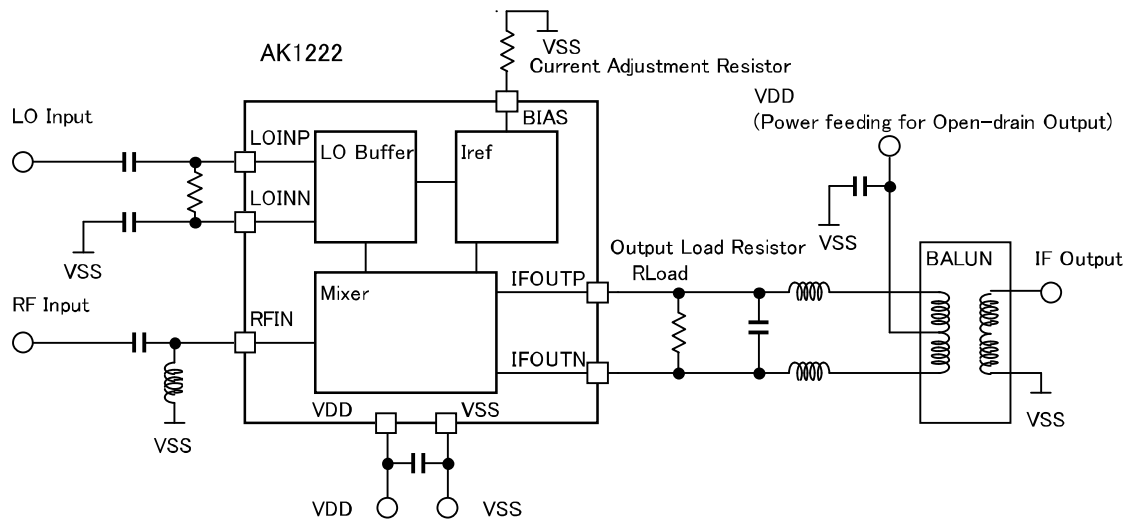


Figure 1. Block Diagram

**6. System Diagram**



**Figure 2. System Diagram**

## 7. Pin Functional Description

Table 1 Pin Function

No.	Name	I/O	Pin Functions	Remarks
1	RFIN	AI	RF Input	Connecting an inductor between this pin and ground.
2	VSS	G	Ground pin	
3	LOINN	AI	LO Input Negative	
4	LOINP	AI	LO Input Positive	
5	NC	-	Non Connect	
6	NC	-	Non Connect	
7	NC	-	Non Connect	
8	NC	-	Non Connect	
9	BIAS	AIO	Resistance pin for current adjustment	Connecting a resistor between this pin and ground.
10	VDD	P	Power Supply	
11	IFOUTN	AO	IF Output Negative	This pin is open drain output. It needs power feeding via an inductor.
12	IFOUTP	AO	IF Output Positive	This pin is open drain output. It needs power feeding via an inductor.
13	NC	-	Non Connect	
14	NC	-	Non Connect	
15	NC	-	Non Connect	
16	NC	-	Non Connect	

Note) It is recommended to connect NC pins to ground, although it will not make any impact on the electrical characteristics if the pin is open.

AI: Analog input pin	AO: Analog output pin	AIO: Analog I/O pin
P: Power supply pin	G: Ground pin	

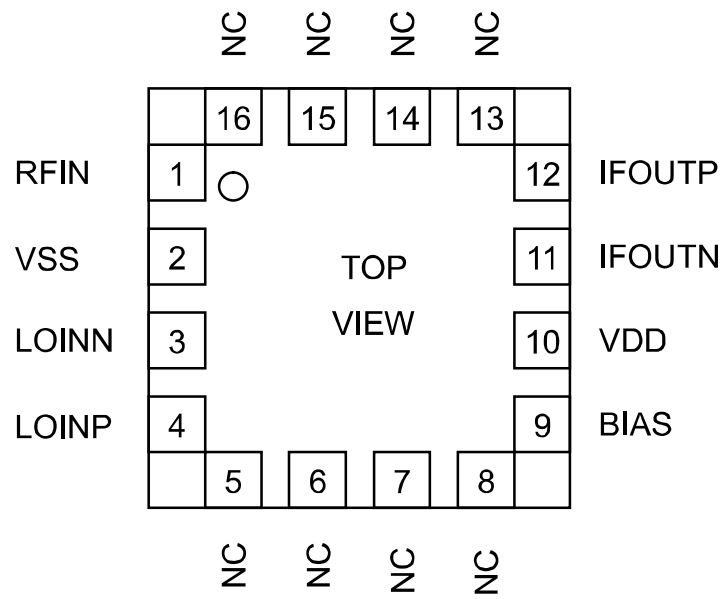


Figure 3. Package Pin Layout

## 8. Absolute Maximum Ratings

**Table 2 Absolute Maximum Ratings**

Parameter	Symbol	Min.	Max.	Unit	Remarks
Supply Voltage	VDD	-0.3	5.5	V	
RF Input Power	RFPOW		7	dBm	
LO Input Power	LOPOW		12	dBm	
Storage Temperature	Tstg	-55	125	°C	

Exceeding these maximum ratings may result in damage to the AK1222. Normal operation is not guaranteed at these extremes.

## 9. Recommended Operating Range

**Table 3 Recommended Operating Range**

Parameter	Symbol	Min.	Typ.	Max.	Unit	Remarks
Operating Temperature	Ta	-40		85	°C	
Supply Voltage	VDD	4.75	5	5.25	V	

The specifications are applicable within the recommended operating range (supply voltage/operating temperature).

## 10. Electrical Characteristics

### 1. Analog Circuit Characteristics

Unless otherwise noted IF output=50MHz, LO Input Level=-5dBm to +5dBm,

Output Load Resistor (R<sub>Load</sub>)=2.2k $\Omega$ , VDD=4.75 to 5.25V, Ta=-40 to 85°C

Parameter		Min.	Typ.	Max.	Unit	Remarks
RF Input Frequency		100		900	MHz	
LO Input Frequency		100		900	MHz	
IF output Frequency		20		100	MHz	
LO Input Power		-5	0	+5	dBm	
Current Adjustment Resistor(BIAS)		22		56	k $\Omega$	
IDD	BIAS=22k $\Omega$		5.3	7.9	mA	The total current of VDD pin, IFOUTP pin and IFOUTN pin.
	BIAS=56k $\Omega$		2.9	4.7	mA	
<b>RFIN=600MHz, Output Load Resistor = 22k<math>\Omega</math></b>						
Conversion Gain		-4	-2	0	dB	
SSB Noise Figure (NF)			12	14	dB	Design guarantee value
IP1dB		-3	0		dBm	
IIP3		+8	+11		dBm	
<b>RFIN=600MHz, Output Load Resistor = 56k<math>\Omega</math></b>						
Conversion Gain		-5.5	-3.5	-1.5	dB	
SSB Noise Figure (NF)			11.5	13.5	dB	Design guarantee value
IP1dB		-9	-6		dBm	
IIP3		-1	+2		dBm	

Note 1) In the shipment test, NC pins and the exposed pad on the center of the back of the package is connected to ground.

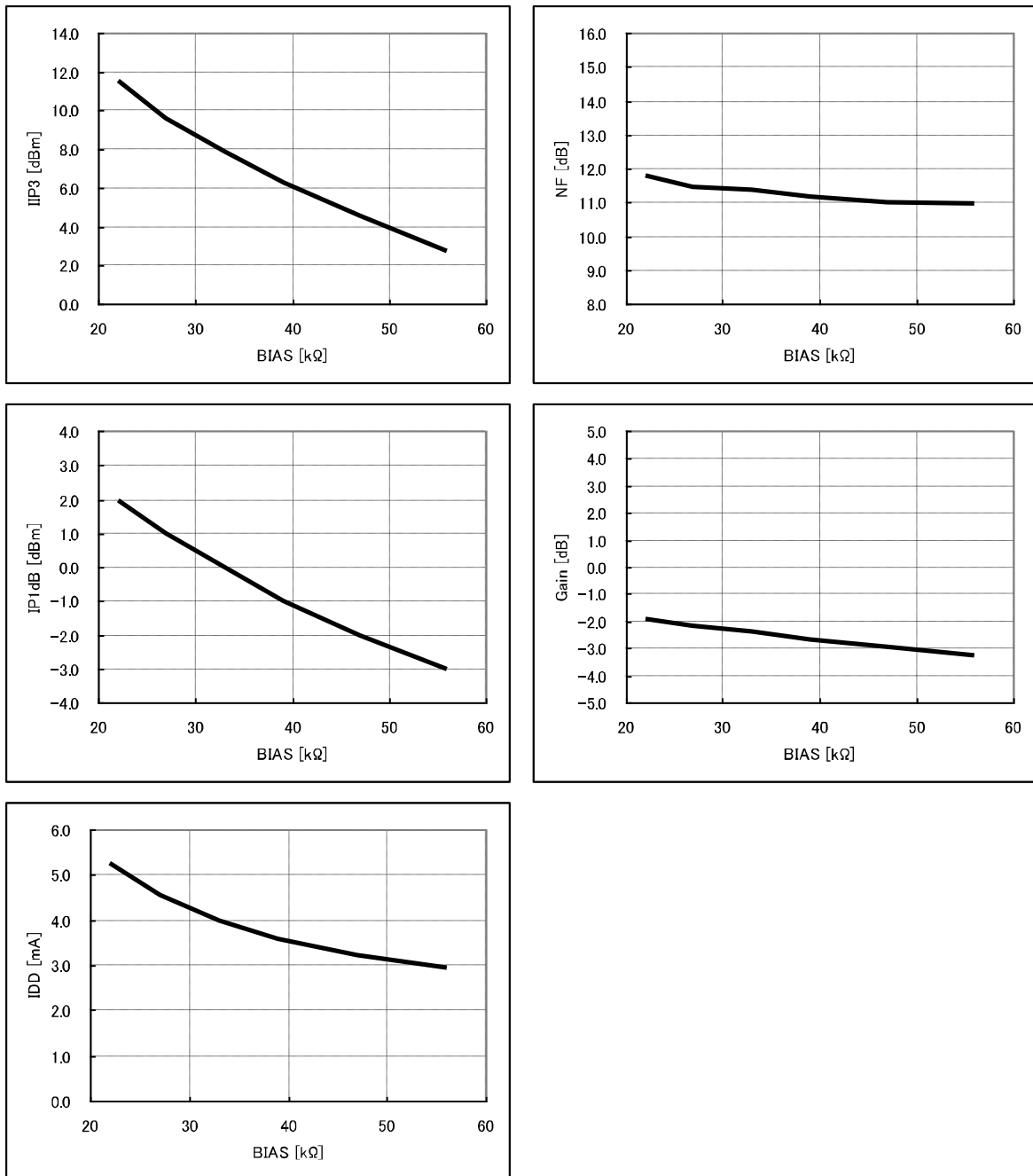


### 11. Typical Performance

Unless otherwise noted, RF input =600MHz, LO input =550MHz, IF output =50MHz,

Output Load Resistor (R<sub>Load</sub>)=2.2kΩ

#### 1. Current Adjustment Resistor vs. IIP3, NF, IP1dB, Gain, IDD



**Figure 4. Current Adjustment Resistor vs. IIP3, NF, IP1dB, Gain, IDD**

Note 1) A resistor with 5% tolerance are used.

2. Over temperature vs. IIP3, NF, IP1dB, Gain, IDD

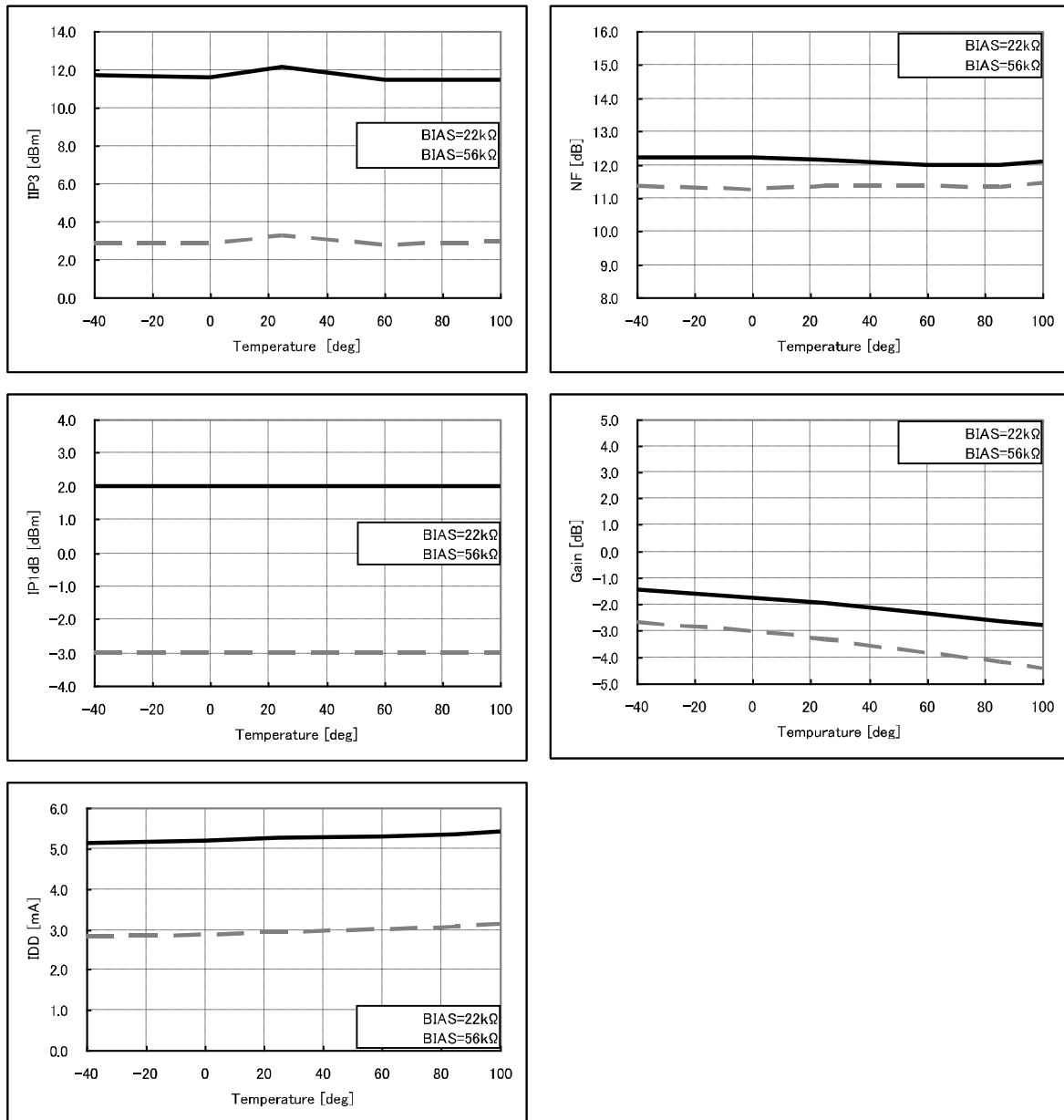


Figure 5. Over temperature vs. IIP3, NF, IP1dB, Gain, IDD

3. Supply voltage vs. IIP3, NF, IP1dB, Gain, IDD

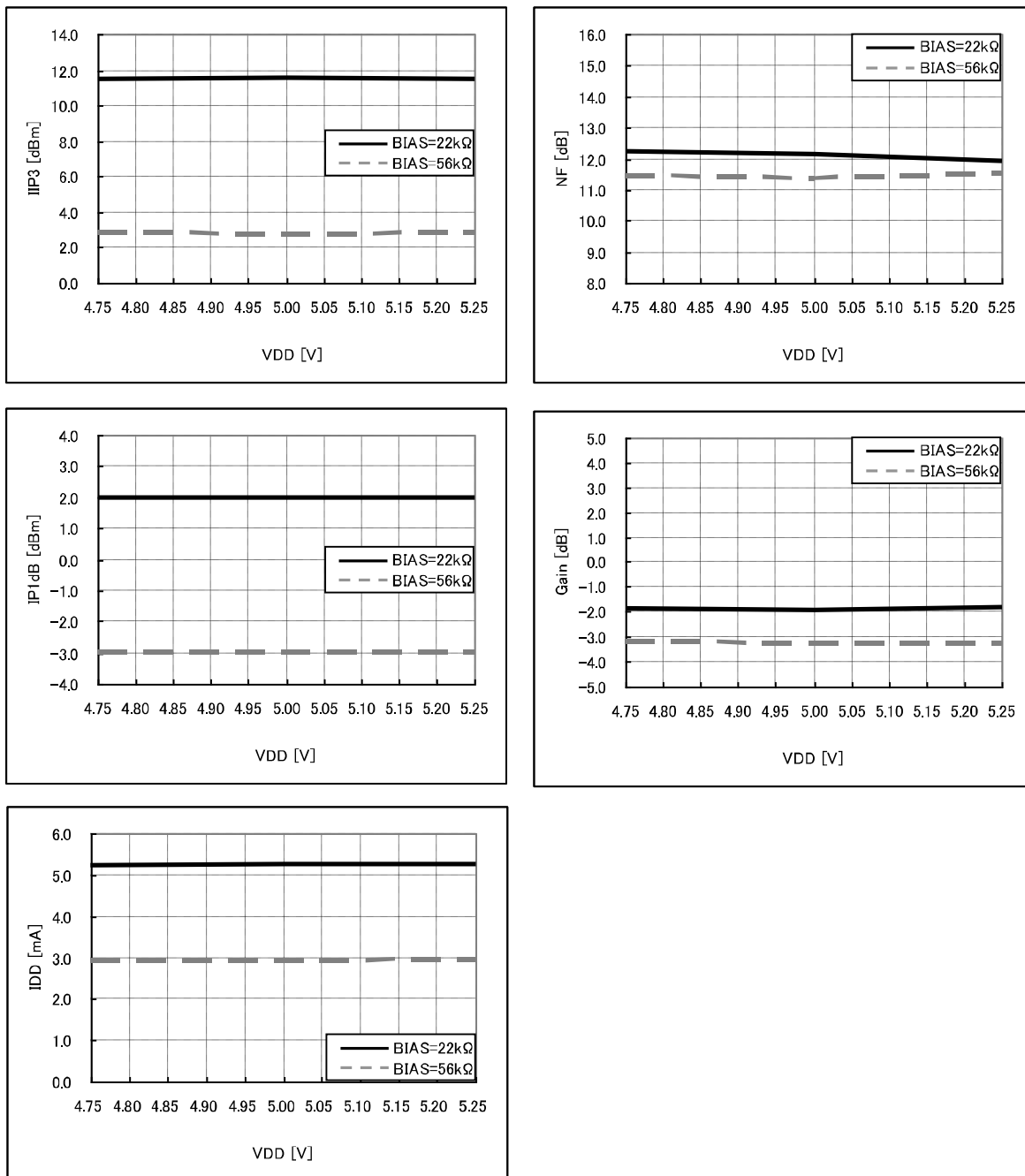


Figure 6. Supply voltage vs. IIP3, NF, IP1dB, Gain, IDD

4. RF input frequency vs. IIP3, NF, IP1dB, Gain

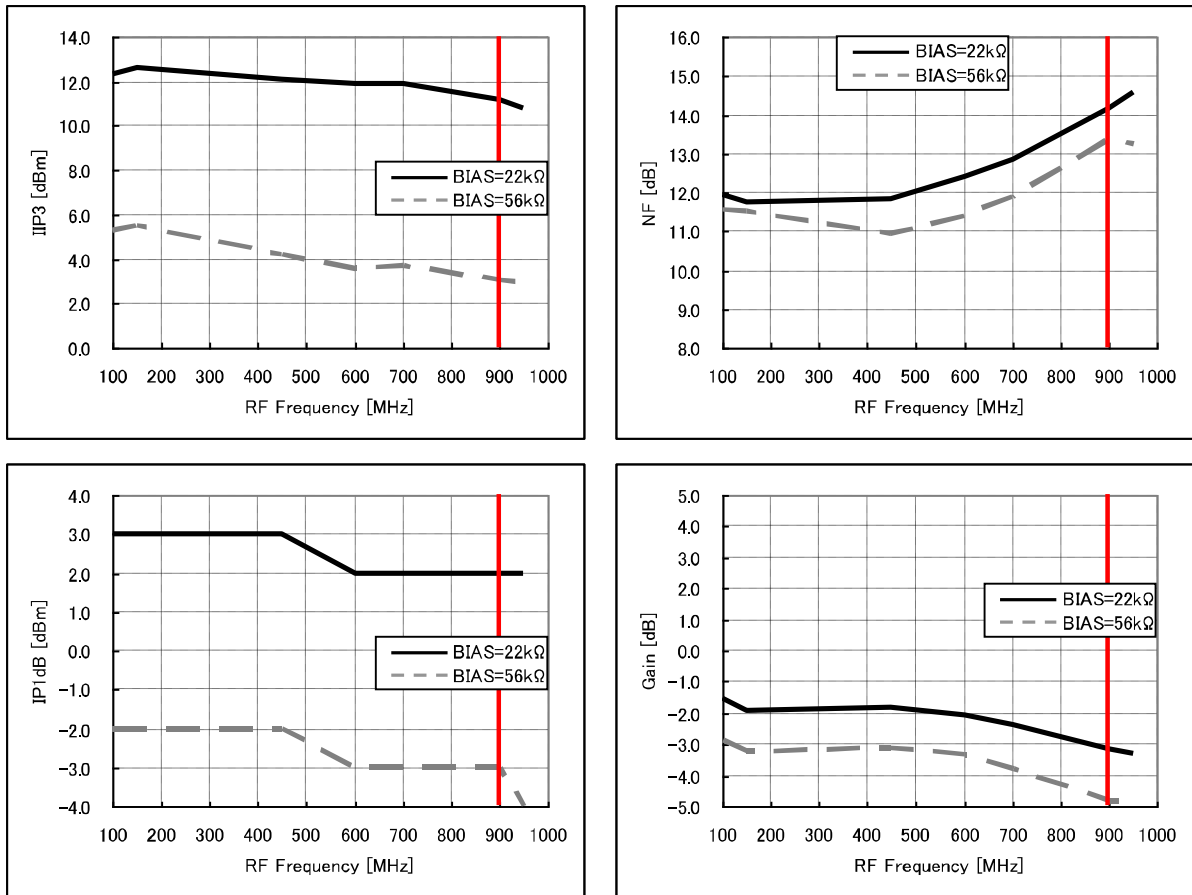


Figure 7. RF input frequency vs. IIP3, NF, IP1dB, Gain

Note 1) AK1222 supports 100MHz to 900MHz RF Input.

5. IF output frequency vs. IIP3, NF, IP1dB, Gain

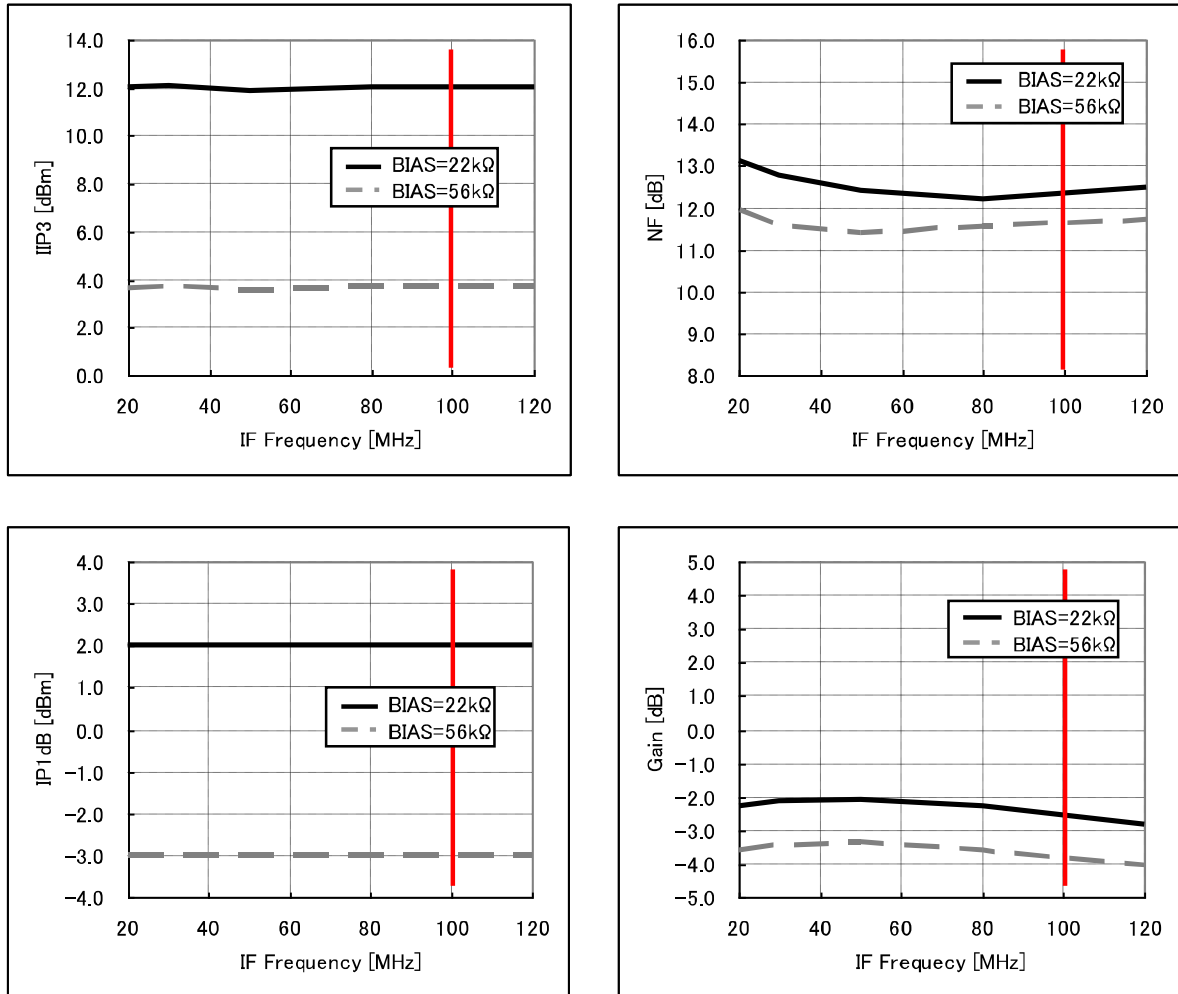


Figure 8. IF output frequency vs. IIP3, NF, IP1dB, Gain

Note 1) AK1222 supports 20MHz to 100MHz IF Output.

6. LO input power vs. IIP3, NF, IP1dB, Gain

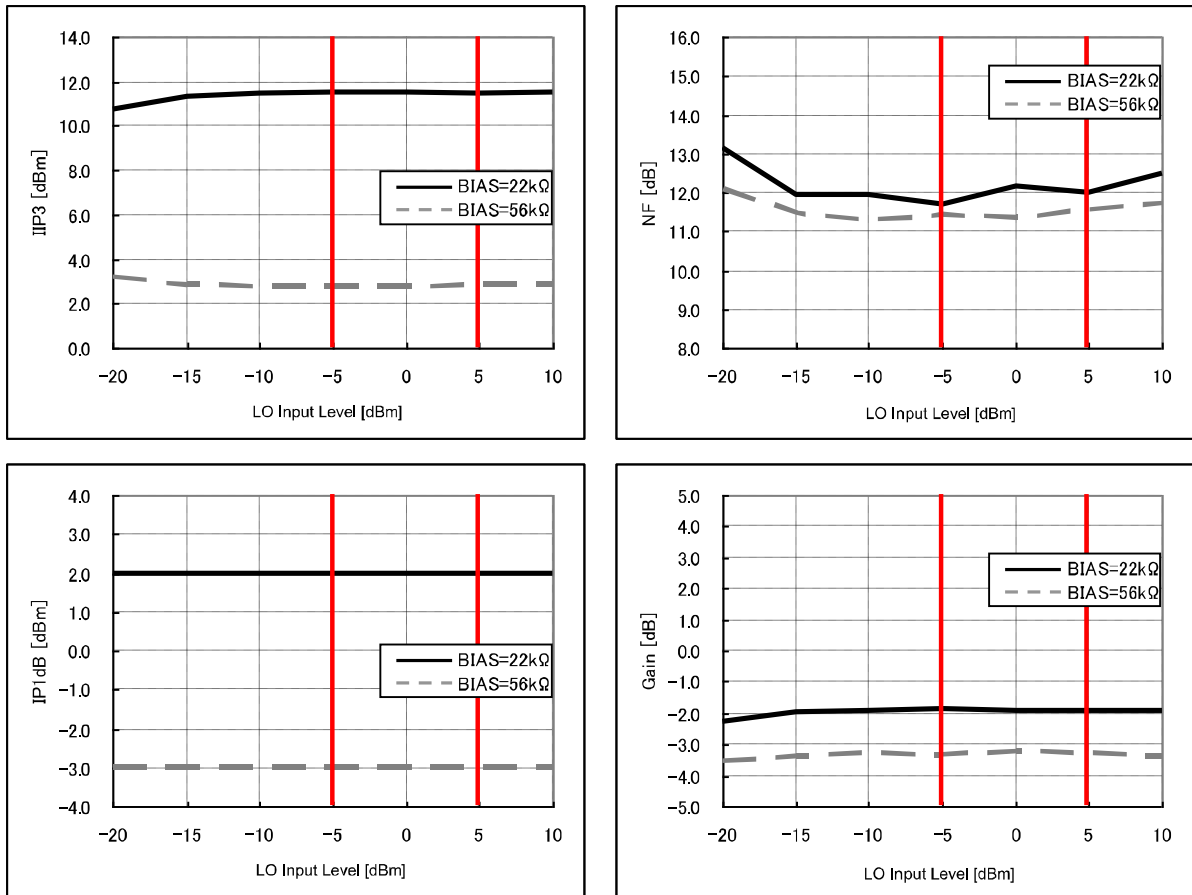


Figure 9. LO input power vs. IIP3, NF, IP1dB, Gain

Note 1) AK1222 supports -5dBm to 5dBm LO input power.

7. Output Load Resistor (RLoad) vs. IIP3, NF, IP1dB, Gain

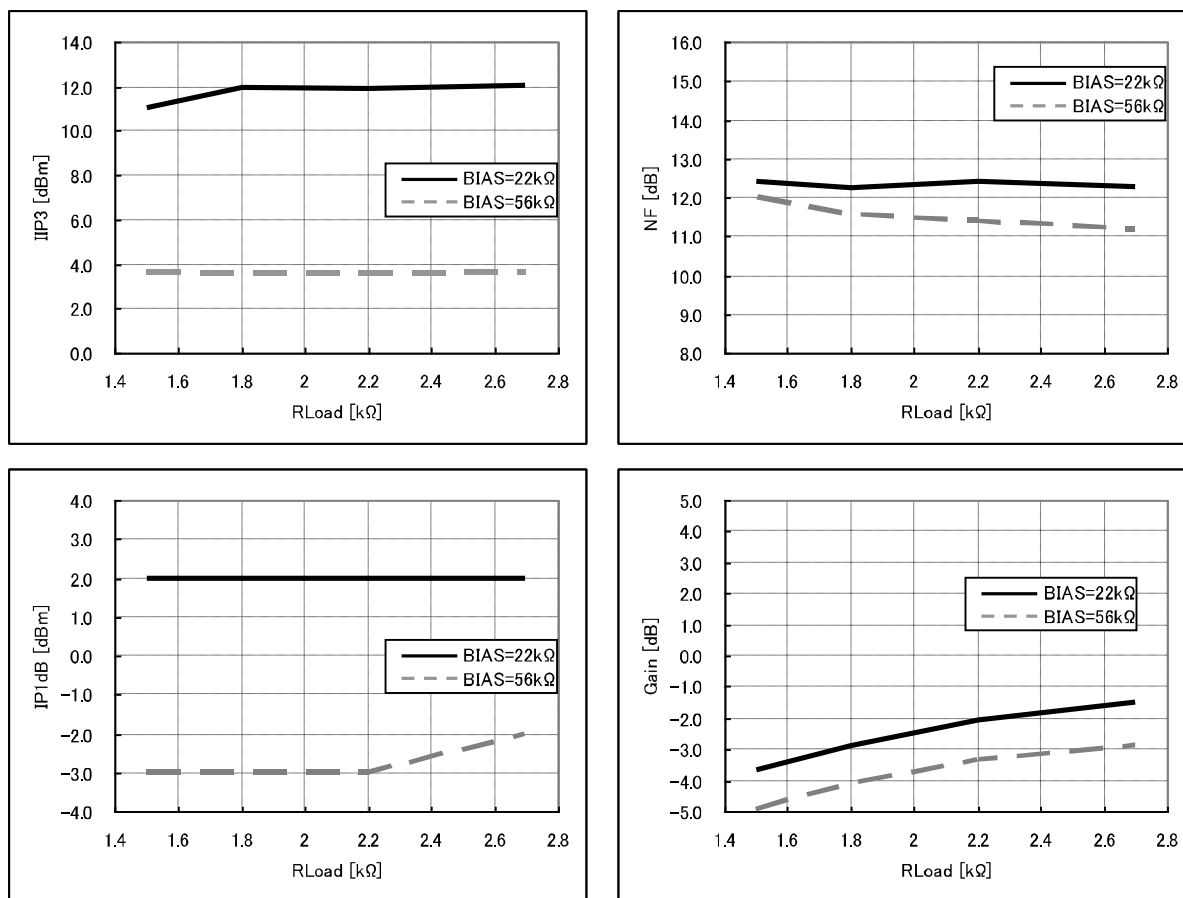


Figure 10. Output Load Resistor (RLoad) vs. IIP3, NF, IP1dB, Gain

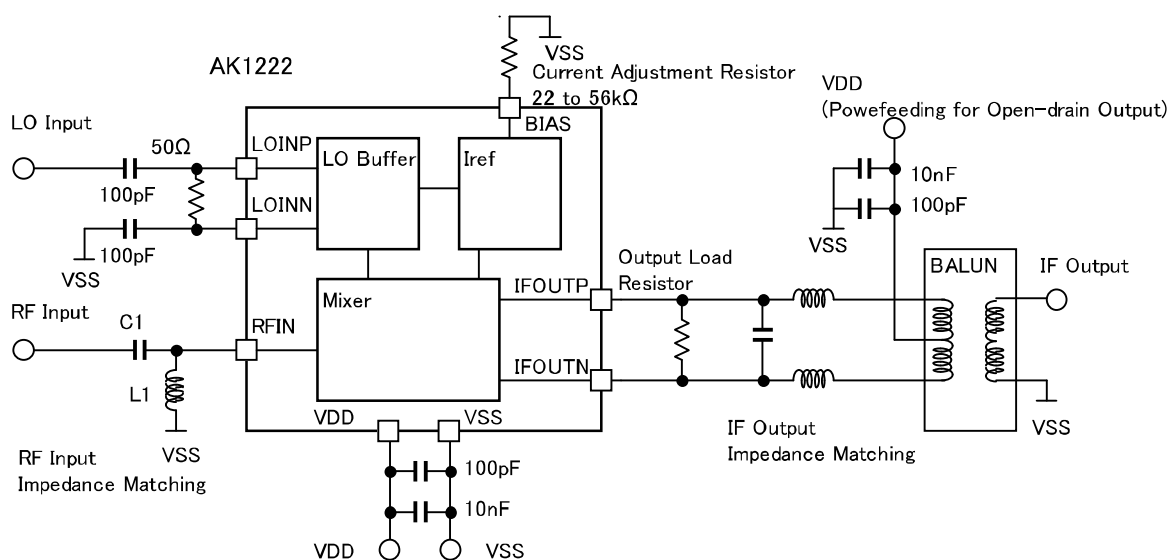
8. Leakage

RF input=600MHz, -20dBm, LO input=600MHz, 0dBm, Ta=25°C VDD=5V

Parameter	BIAS	Typ.	Unit
RF – LO Leakage	22kΩ	-50	dBc
	56kΩ	-50	dBc
RF – IF Leakage	22kΩ	-80	dBc
	56kΩ	-80	dBc
LO – RF Leakage	22kΩ	-50	dBc
	56kΩ	-50	dBc
LO – IF Leakage	22kΩ	-80	dBc
	56kΩ	-80	dBc

**12. Typical Evaluation Board Schematic**

**1. Typical Evaluation Board Schematic**



**Figure 11. Typical Evaluation Board Schematic**

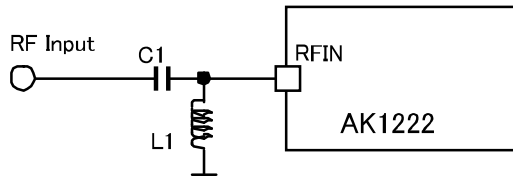
Note 1) The open drain output needs power feeding via a inductor. (IFOUTP pin and IFOUTN)

Note 2) It is necessary to adjust impedance matching as to its setting frequency. (RF input and IF output)

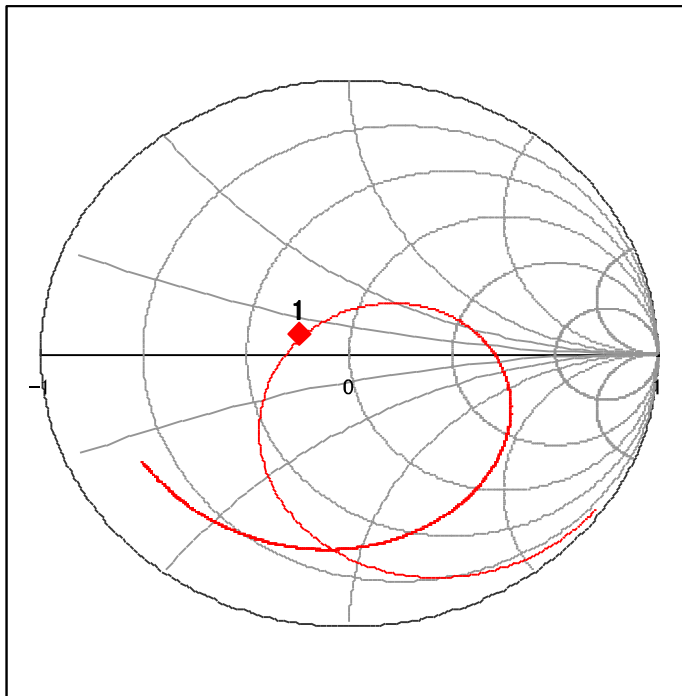


2. Example of impedance matching

•RFIN



Frequency[MHz]	C1[pF]	L1[nH]
150	15	82
450	5.1	22
600	3.6	15
900	3.9	6.8



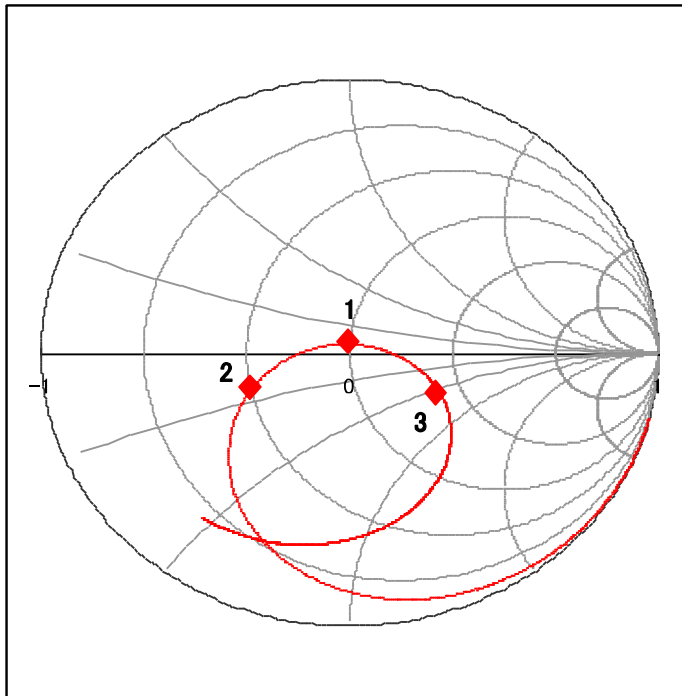
Frequency[MHz]	C1[pF]	L1[nH]
150	15	82

Start 50MHz, Stop 1GHz

Marker 1

150MHz: 36.1Ω 4.2Ω

Figure 12. RFIN 150MHz example of impedance matching



Frequency[MHz]	C1[pF]	L1[nH]
450	5.1	22

Start 50MHz, Stop 1GHz

Marker 1

450MHz: 51.1Ω 3.3Ω

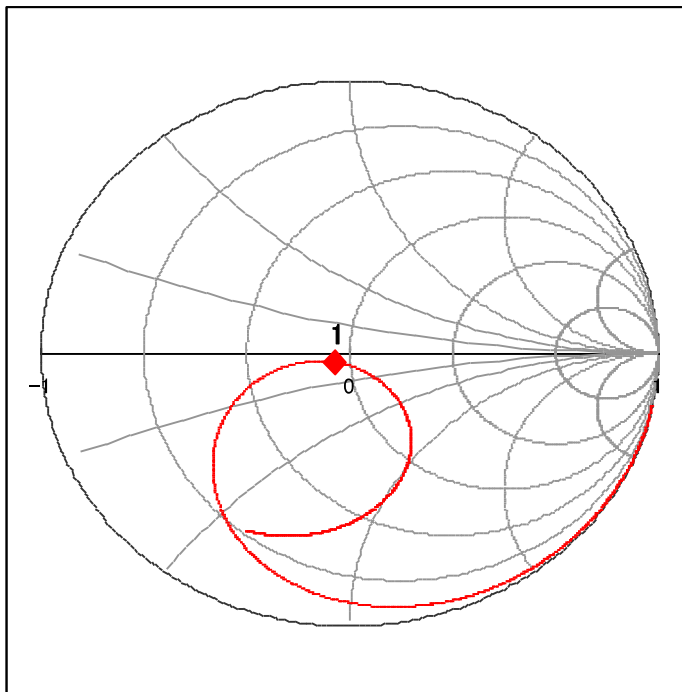
Marker 2

394MHz: 25.1Ω -7.6Ω

Marker 3

524MHz: 85.6Ω -30.1Ω

Figure 13. RFIN 450MHz example of impedance matching



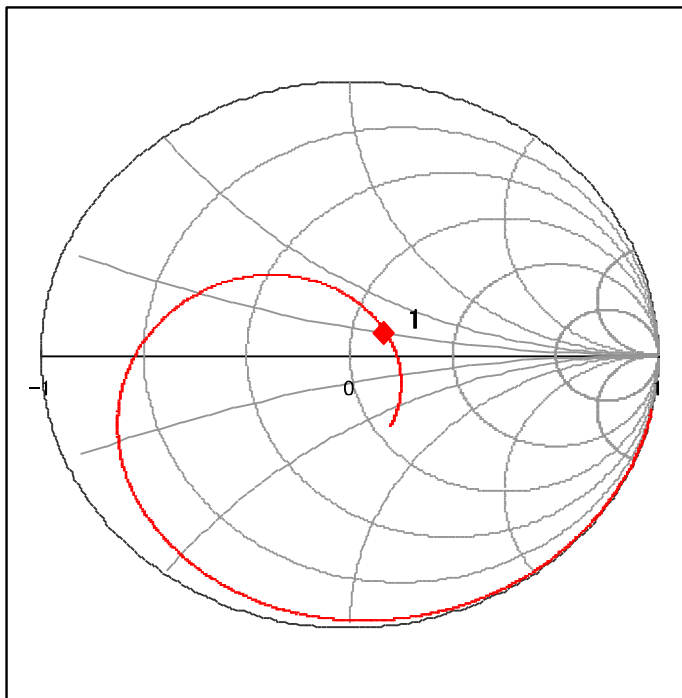
Frequency[MHz]	C1[pF]	L1[nH]
600	3.6	15

Start 50MHz, Stop 1GHz

Marker 1

600MHz: 46.2Ω -3.3Ω

Figure 14. RFIN 600MHz example of impedance matching



Frequency[MHz]	C1[pF]	L1[nH]
900	3.9	6.8

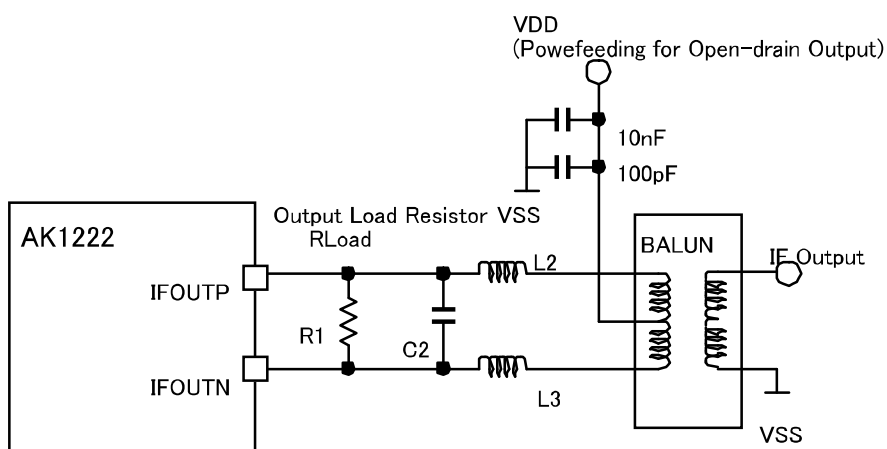
Start 50MHz, Stop 1GHz

Marker 1

900MHz:  $61.8\Omega$   $11.0\Omega$

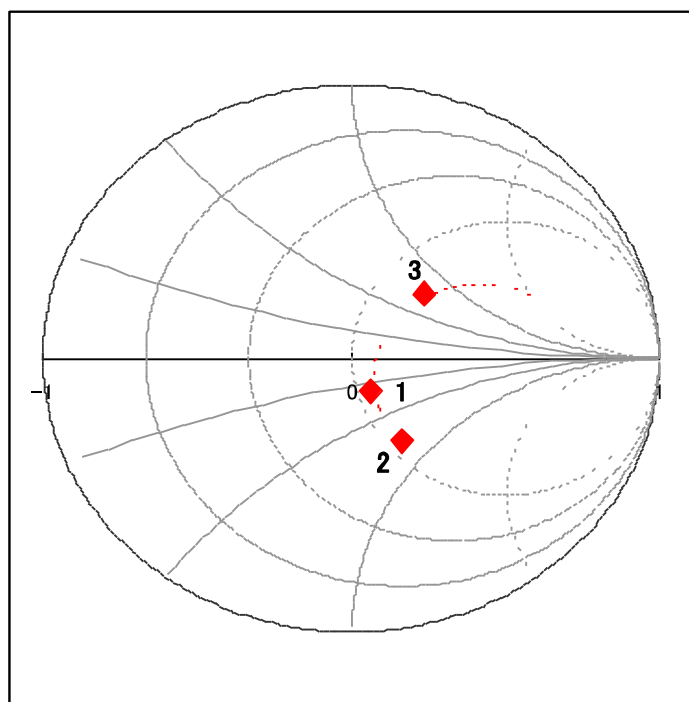
Figure 15. RFIN 900MHz example of impedance matching

•IFOUT



Frequency [MHz]	R1 [kΩ]	C2 [pF]	L2 [nH]	L3 [nH]
30	2.2	3.9	1800	1800
50	2.2	2.0	1000	1000
60	2.2	0.5	1000	1000
80	2.2	N/A	680	680
100	2.2	N/A	470	470

1800nH : Murata LQW21HN1R8J00L  
 1000nH : Murata LQW21HN1R0J00L  
 680nH : Murata LQW21HNR68J00L  
 470nH : Murata LQW21HNR47J00L  
 BALUN:Mini-Circuits ADT4-6T+

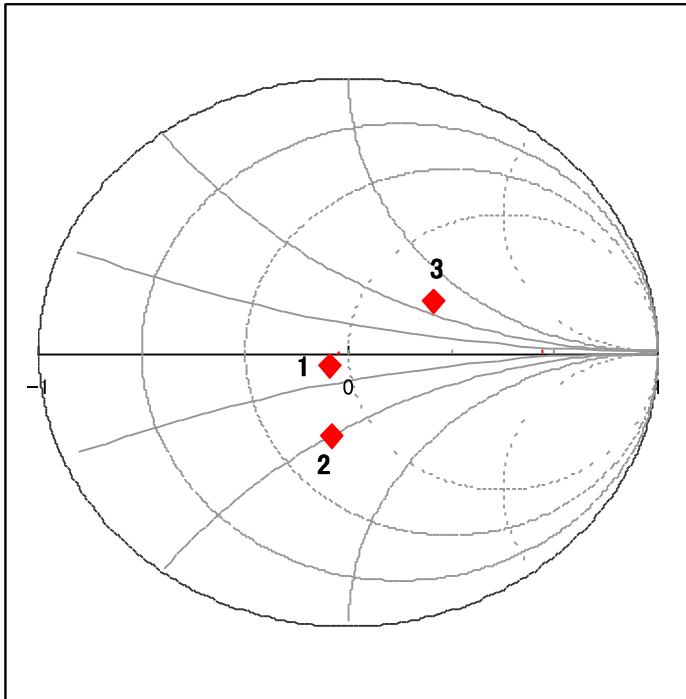


Frequency [MHz]	R1 [kΩ]	C2 [pF]	L2 [nH]	L3 [nH]
30	2.2	3.9	1800	1800

Start 10MHz, Stop 140MHz

- Marker 1  
30MHz: 55.5Ω -19.7Ω
- Marker 2  
28MHz: 55.7Ω -37.3Ω
- Marker 3  
36MHz: 72.8Ω 38.4Ω

Figure 16. IFOUT 30MHz example of impedance matching



Frequency [MHz]	R1 [kΩ]	C2 [pF]	L2 [nH]	L3 [nH]
50	2.2	2	1000	1000

Start 10MHz, Stop 140MHz

Marker 1

50MHz: 43.2Ω -7.5Ω

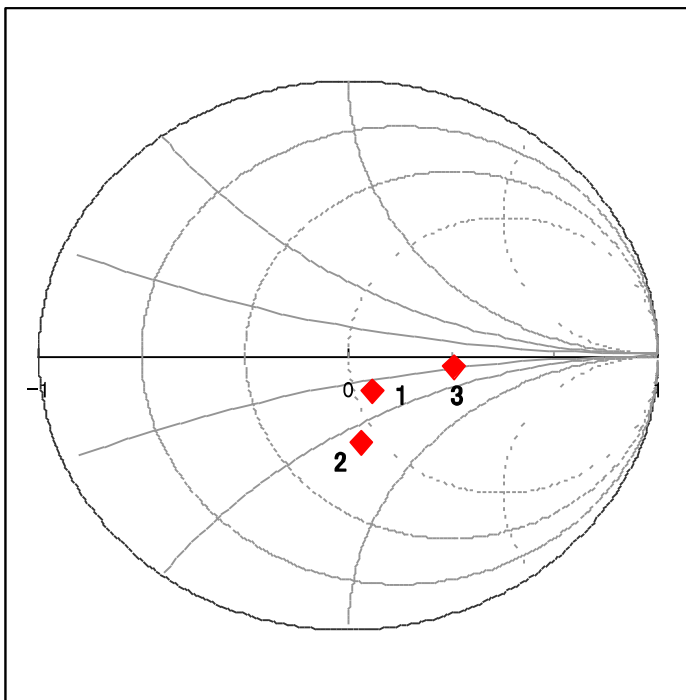
Marker 2

45MHz: 37.3Ω -28.6Ω

Marker 3

59MHz: 81.6Ω 34.6Ω

Figure 17. IFOUT 50MHz example of impedance matching



Frequency [MHz]	R1 [kΩ]	C2 [pF]	L2 [nH]	L3 [nH]
60	2.2	0.5	1000	1000

Start 10MHz, Stop 140MHz

Marker 1

60MHz: 52.7Ω -19.0Ω

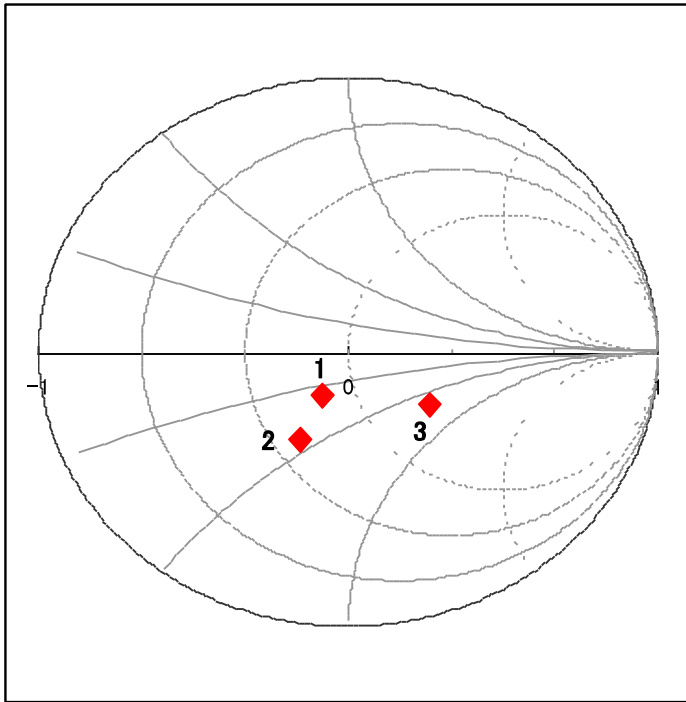
Marker 2

54MHz: 43.4Ω -33.1Ω

Marker 3

70MHz: 100.7Ω -8.4Ω

Figure 18. IFOUT 60MHz example of impedance matching



Frequency [MHz]	R1 [kΩ]	C2 [pF]	L2 [nH]	L3 [nH]
80	2.2	N/A	680	680

Start 10MHz, Stop 140MHz

Marker 1

80MHz: 38.5Ω -14.5Ω

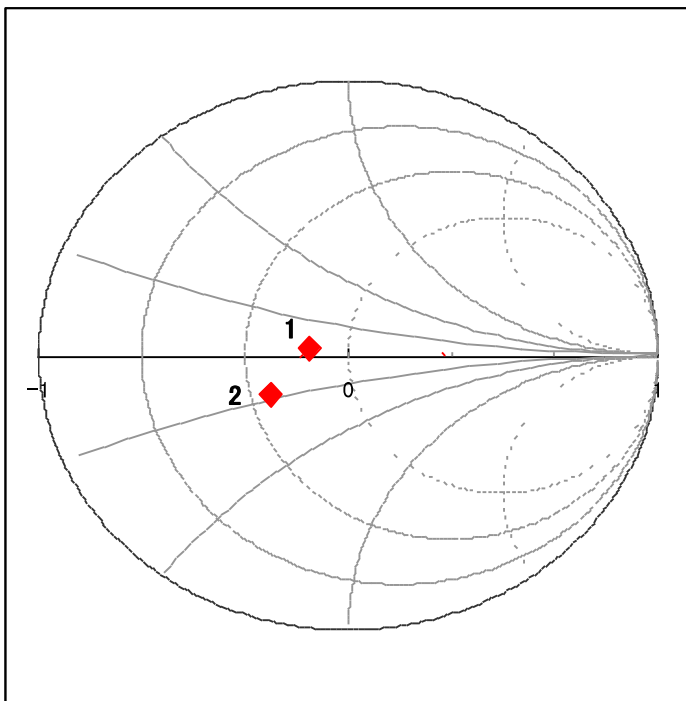
Marker 2

75MHz: 31.2Ω -21.3Ω

Marker 3

95MHz: 78.7Ω -33.8Ω

Figure 19. IFOUT 80MHz example of impedance matching



Frequency [MHz]	R1 [kΩ]	C2 [pF]	L2 [nH]	L3 [nH]
100	2.2	N/A	470	470

Start 10MHz, Stop 140MHz

Marker 1

100MHz: 38.9Ω 1.6Ω

Marker 2

90MHz: 26.9Ω -12.2Ω

Figure 20. IFOUT 100MHz example of impedance matching

## • LOINP/LOINN

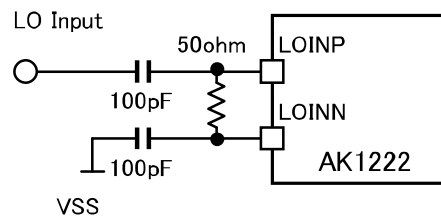


Figure 21. LOINP/LOINN example of impedance matching

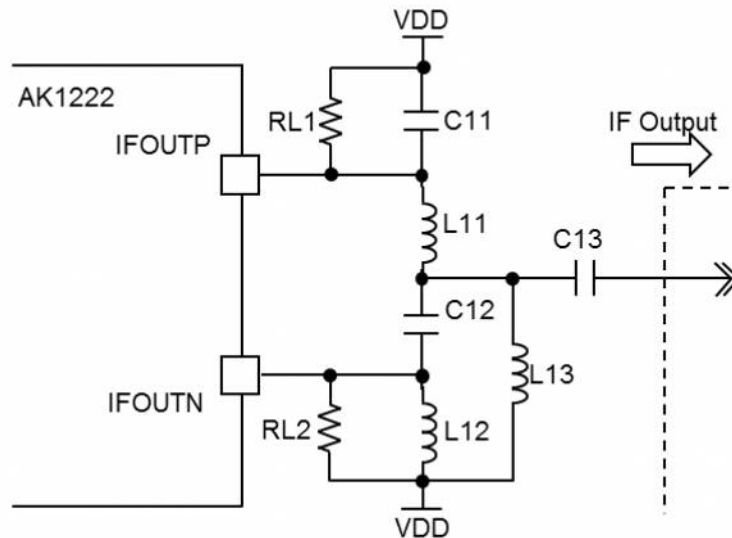
**13. IC Interface Schematic**

No.	Name	I/O	Function
1	RFIN	I	RF input pin
3	LOINN	I	LO input pins
4	LOINP	I	
9	BIAS	I/O	Analog I/O pin
11	IFOUTN	O	IF output pins
12	IFOUTP	O	



## 14. Application Information

### •Impedance matching network with LC



**Figure 22. Impedance matching network with LC**

Impedance matching network with LC is shown in Figure 22. AK1222 has open drain outputs, so  $RL1 + RL2$  is output load resistance.  $C11$  and  $L11$  compose lowpass filter.  $C12$  and  $L12$  are for highpass filter.  $C13$  is DC blocking capacitor and  $L13$  is RF choke. IFOUTP and IFOUTN pins need power feeding via  $L11$ ,  $L12$  and  $L13$ .

The differential voltage from IFOUTP/N can be converted to a single-ended by  $L11$ ,  $L12$ ,  $C11$  and  $C12$  properly. The differential impedance ( $RL1 + RL2$ ) is converted to single-ended output terminating impedance  $R_o$ .

$L11$ ,  $C11$ ,  $L12$  and  $C12$  are calculated as below.  $f_{out}$  is IF output frequency.

$$C_{11} = C_{12} = \frac{1}{2\pi * f_{OUT} * \sqrt{(R_{L1} + R_{L2}) * R_o}}$$

$$L_{11} = L_{12} = \frac{\sqrt{(R_{L1} + R_{L2}) * R_o}}{2\pi * f_{OUT}}$$

For example, in the case of IF Output = 50MHz, Output Load Resistor ( $R_{load}$ ) = 2.2k $\Omega$  in 50 $\Omega$  interface,  $L11$ ,  $C11$ ,  $L12$  and  $C12$  are calculated as below.

$$C_{11} = C_{12} = \frac{1}{2\pi * (50 * 10^6) * \sqrt{(2.2 * 10^3) * 50}} = 9.6\text{pF}$$

$$L_{11} = L_{12} = \frac{\sqrt{(2.2 * 10^3) * 50}}{2\pi * (50 * 10^6)} = 1056\text{nH}$$

L13 and C13 should be large enough not to affect the impedance at IF output frequency. In some cases the impedance matching can be optimized by L13 and C13.

For example, in the case of IF Output = 50MHz, Output Load Resistor (Rload) = 2.2kΩ in 50Ω interface, it is recommended to choose 2200nH and 1000pF as L13 and C13. If any correction is needed, it can be adjusted by reducing the value of L13 and C13.

These calculated values are approximation. In some cases, some correction is needed due to the effect of parasitic capacitance of external parts or/and PCBs. The impedance matching network components should be decided through enough evaluation on AK1222.

Typical Performance using impedance matching network with LC is below. RF Input = 600MHz, IF Output = 50MHz, LO Input = 550MHz, Output Load Resistor (Rload) = 2.2kΩ, Vdd = 5V, Ta = 25°C, LO Input Level = 0dBm.

Ref.	Value	Size	Part Number
RL1, RL2	1.1kΩ	1005	KOA RK73K1ETP112
L11, L12	1000nH	2012	Murata LQW21HN1R0J00
C11, C12	10pF	1005	Murata GRM1552C1H100JA01
L13	2200nH	2012	Murata LQW21HN2R2J00
C13	150pF	1005	Murata GRM1552C1H151JA01

Parameter	Rbias	Min.	Typ.	Max.	Unit
Conversion Gain	Rbias = 22k $\Omega$ ( $\cong$ 5.3mA)		-2.3		dB
	Rbias = 56k $\Omega$ ( $\cong$ 2.9mA)		-3.7		
SSB Noise Figure (NF)	Rbias = 22k $\Omega$ ( $\cong$ 5.3mA)		11.5		dB
	Rbias = 56k $\Omega$ ( $\cong$ 2.9mA)		10.5		
IP1dB	Rbias = 22k $\Omega$ ( $\cong$ 5.3mA)		0.0		dBm
	Rbias = 56k $\Omega$ ( $\cong$ 2.9mA)		-5.5		
IIP3	Rbias = 22k $\Omega$ ( $\cong$ 5.3mA)		12.0		dBm
	Rbias = 56k $\Omega$ ( $\cong$ 2.9mA)		3.8		

The phase and amplitude balance is achieved at IF Output frequency by using impedance matching network with LC. The port-to-port leakage is improved with the phase and amplitude balance is achieved at RF, LO, and IF frequency with wide band balun.

•Evaluation Board

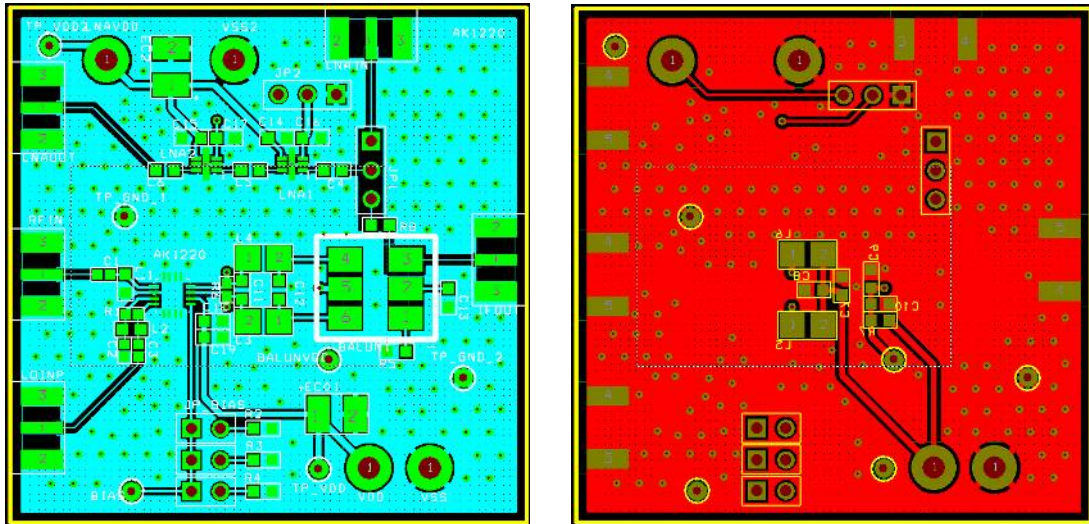


Figure 23. AK1220/AK1222 Evaluation Board (Balun)

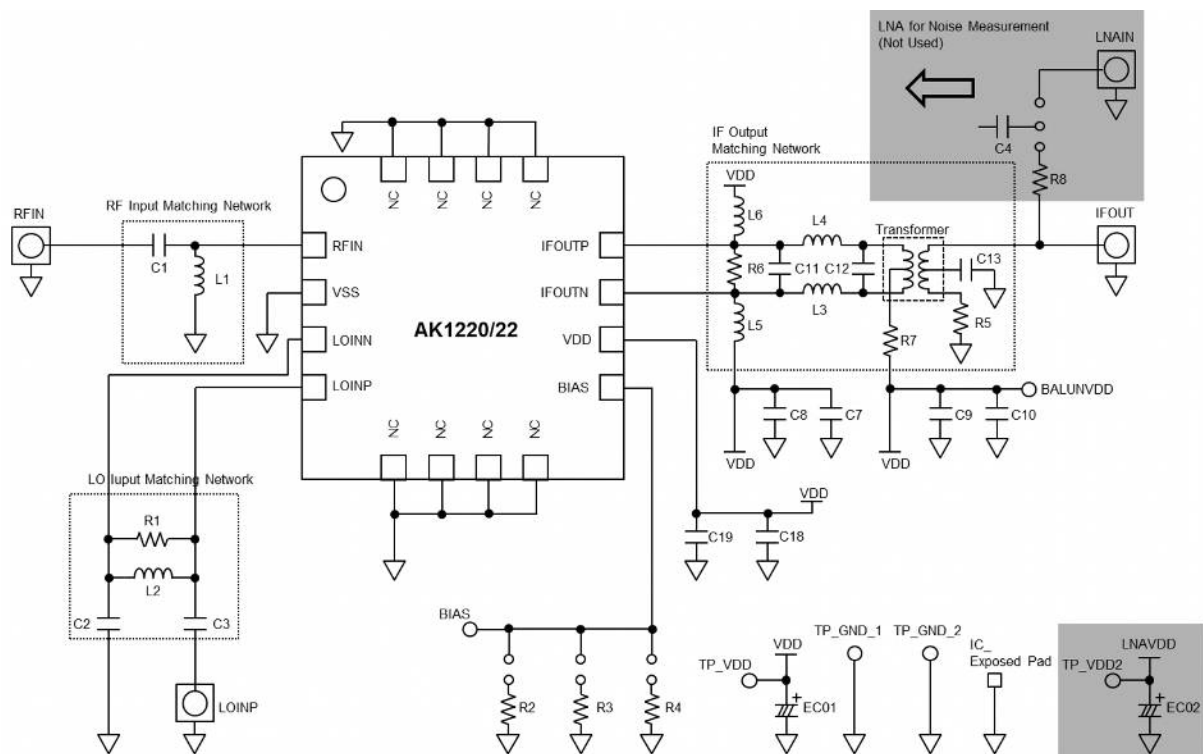


Figure 24. AK1220/AK1222 Evaluation Board Schematic (Balun)

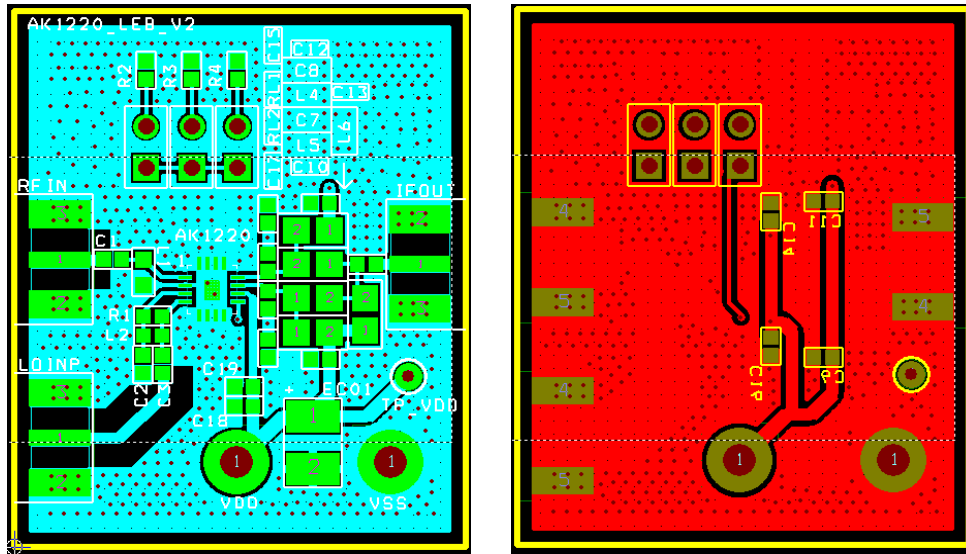


Figure 25. AK1220/AK1222 Evaluation Board (matching network with LC)

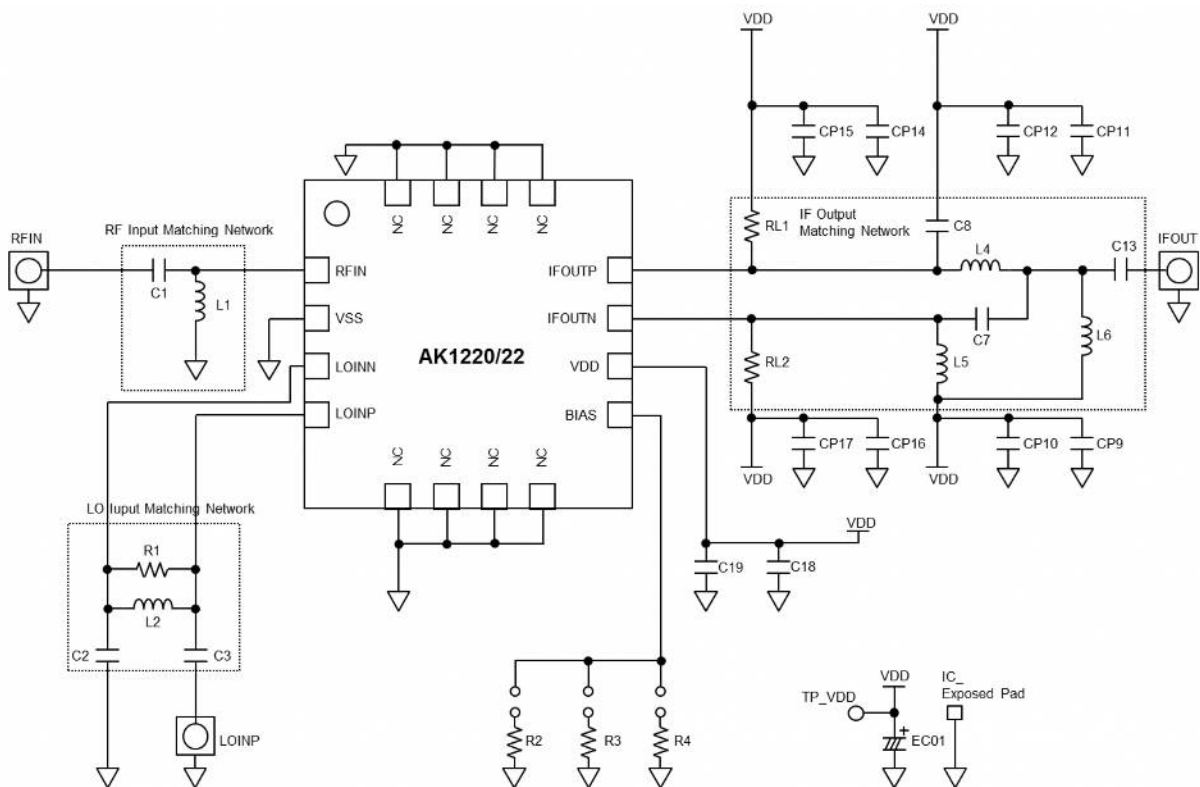
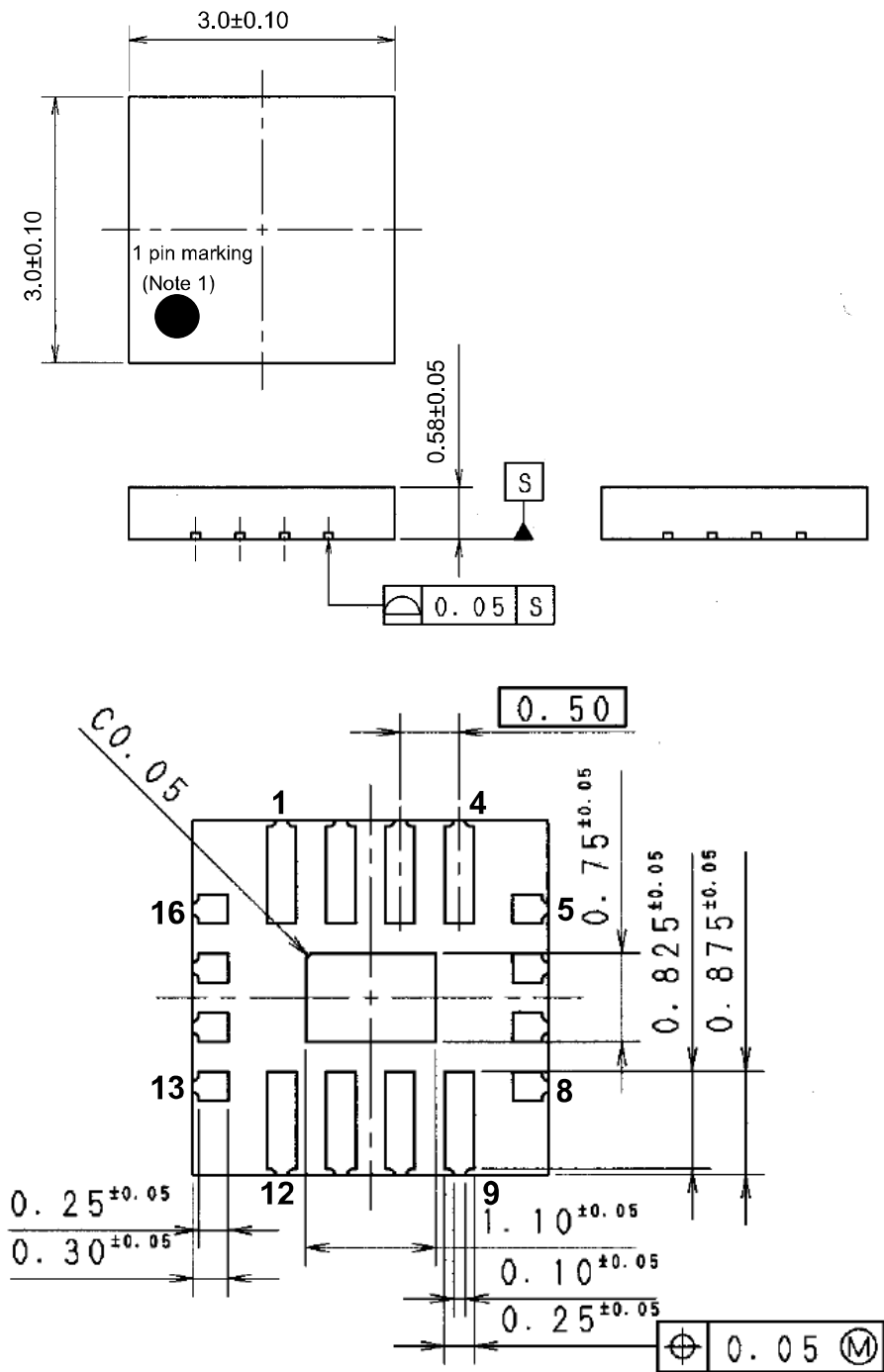


Figure 26. AK1220/AK1222 Evaluation Board Schematic (matching network with LC)

**15. Outer Dimensions**

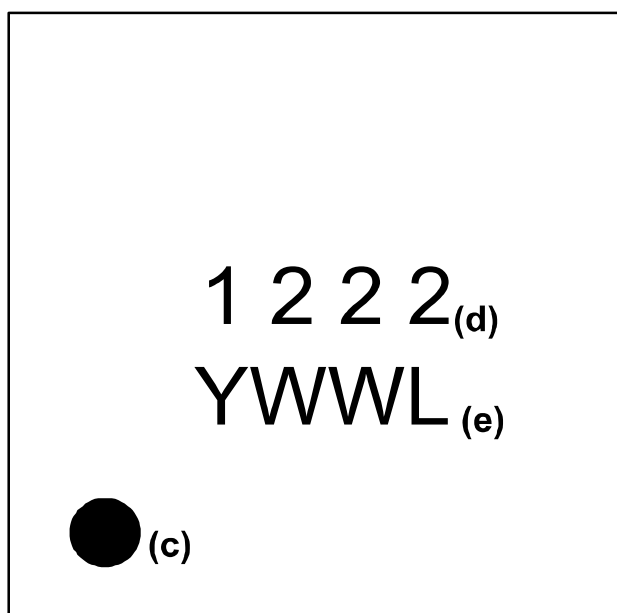


**Figure 27. Outer Dimensions**

Note 1. 1 pin marking is only a reference for the 1 pin location on the top of package.

**16. Marking**

- (a) Style : QFN  
(b) Number of pins : 16  
(c) 1 pin marking: : ○  
(d) Product number : 1222  
(e) Date code : YWWL (4 digits)  
Y: Lower 1 digit of calendar year (Year 2011 → 1, 2012 → 2 ...)  
WW: Week  
Lot identification, given to each product lot which is made in a week  
→ LOT ID is given in alphabetical order (A, B, C...).

**Figure 28. Marking**

## IMPORTANT NOTICE

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### •Related Parts

Part#	Discription	Comments
<b>Mixer</b>		
AK1220	100MHz~900MHz High Linearity Down Conversion Mixer	IIP3:+22dBm
AK1222	100MHz~900MHz Low Power Down Conversion Mixer	IDD:2.9mA
AK1224	100MHz~900MHz Low Noise, High Linarity Down Conversion Mixer	NF:8.5dB, IIP3:+18dBm
AK1228	10MHz~2GHz Up/Down Conversion Mixer	3V Supply, NF:8.5dB
AK1221	0.7GHz~3.5GHz High Linearity Down Conversion Mixer	IIP3:+25dBm
AK1223	3GHz~8.5GHz High Linearity Down Conversion Mixer	IIP3:+13dB, NF:15dB
<b>PLL Synthesizer</b>		
AK1541	20MHz~600MHz Low Power Fractional-N Synthesizer	IDD:4.6mA
AK1542A	20MHz~600MHz Low Power Integer-N Synthesizer	IDD:2.2mA
AK1543	400MHz~1.3GHz Low Power Fractional-N Synthesizer	IDD:5.1mA
AK1544	400MHz~1.3GHz Low Power Integer-N Synthesizer	IDD:2.8mA
AK1590	60MHz~1GHz Fractional-N Synthesizer	IDD:2.5mA
AK1545	0.5GHz~3.5GHz Integer-N Synthesizer	16-TSSOP
AK1546	0.5GHz~3GHz Low Phase Noise Integer-N Synthesizer	Normalized C/N:-226dBc/Hz
AK1547	0.5GHz~4GHz Integer-N Synthesizer	5V Supply
AK1548	1GHz~8GHz Low Phase Noise Integer-N Synthesizer	Normalized C/N:-226dBc/Hz
<b>IFVGA</b>		
AK1291	100~300MHz Analog Signal Control IF VGA w/ RSSI	Dynamic Range:30dB
<b>integrated VCO</b>		
AK1572	690MHz~4GHz Down Conversion Mixer with Frac.-N PLL and VCO	IIP3:24dBm, -111dBc/Hz@100kHz
AK1575	690MHz~4GHz Up Conversion Mixer with Frac.-N PLL and VCO	IIP3:24dBm, -111dBc/Hz@100kHz
<b>IF Reciever (2nd Mixer + IF BPF + FM Detector)</b>		
AK2364	Built-in programmable AGC+BPF, FM detector IC	IFBPF:±10kHz ~ ±4.5kHz
AK2365A	Built-in programmable AGC+BPF, IFIC	IFBPF:±7.5kHz ~ ±2kHz
<b>Analog BB for PMR/LMR</b>		
AK2345	CTCSS Filter, Encoder, Decoder	24-VSOP
AK2360/ AK2360A	Inverted frequency(3.376kHz/3.020kHz) scrambler	8-SON
AK2363	MSK Modem/DTMF Receiver	24-QFN
AK2346B	0.3-2.55/3.0kHz Analog audio filter,	24-VSOP
AK2346A	Emphasis, Compandor, scrambler, MSK Modem	24-QFN
AK2347B	0.3-2.55/3.0kHz Analog audio filter	24-VSOP
AK2347A	Emphasis, Compandor, scrambler, CTCSS filter	24-QFN
<b>Function IC</b>		
AK2330	8-bit 8ch Electronic Volume	VREF can be selected for each channel
AK2331	8-bit 4ch Electronic Volume	VREF can be selected for each channel

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